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Development of a New Korean Standard Bone Age Model: A Paradigm for AI-Powered Pediatric Imaging

Jung-Eun Cheon[1,2,3]

[1]Department of Radiology, Seoul National University College of Medicine, Seoul, Republic of Korea
[2]Division of Pediatric Radiology, Seoul National University Children's Hospital, Seoul, Republic of Korea
[3]Institute of Radiation Medicine, Seoul National University Medical Research Center, Seoul, Republic of Korea

See the corresponding article "Bone Age Assessment Using Artificial Intelligence in Korean Pediatric Population: A Comparison of Deep-Learning Models Trained With Healthy Chronological and Greulich-Pyle Ages as Labels" by Kim et al., in volume 24(11) on page 1151 to 1163, https://doi.org/10.3348/kjr.2023.0092.

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The assessment of skeletal maturity, also known as bone age, using hand and wrist radiography is a crucial clinical method for diagnosing and treating endocrinological abnormalities and growth disturbances in children [1]. The Greulich and Pyle (GP) atlas, containing a reference set of standard hand images obtained from 1000 healthy white children in Cleveland, Ohio, from 1931 to 1942, is the most commonly used method for assessing bone age using hand and wrist radiographs [2]. Over the last three decades, many authors have raised concerns regarding the appropriateness of using the GP atlas to assess bone age in contemporary children. Even when accounting for differences based on race and ethnicity, it may not be reasonable to directly apply the standards of bone age from the 1930s to the children and adolescents of today, considering the changes in nutritional status and overall health condition [3,4].

In 1999, Yeon and Kim [5] published a book, "Atlas of Korean Standard Bone Age," providing standard bone age charts based on Tanner-Whitehouse 2 (TW2)-20 scores for Korean children using 3407 hand and wrist radiographs. This 3-year project began in 1994, and the results were published in 1997 [6]. The chart outlines the age range of the standard bone age references for Korean children and has been correlated with the GP and Tanner-Whitehouse 3 (TW3) methods [7]. However, the Korean standard bone-age chart has not been widely used in clinical practice. The GP atlas has been more popularly used in Korea, and the GP-based automated bone age assessment software developed by Korean vendors is commonly used in clinical practice.

Kim et al. [8] developed a deep learning-based bone age prediction model optimized for Korean children and adolescents using 21036 hand and wrist radiographs, and then evaluated its feasibility by comparing it with a GP-based deep learning model. This study has several clinical implications. First, the deep learning-based Korean model demonstrated better accuracy in predicting bone age than the conventional GP-based method. This improved accuracy is particularly important for accurate growth assessment and clinical decision-making. Second, the GP-based method exhibited a systemic bias in bone age prediction, leading to the underestimation of bone age before the age of 8 years and the overestimation of bone age after the age of 8 years. The Korean bone-age model minimizes this bias and provides more accurate age predictions across various age groups. Third, this study emphasizes the importance

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Corresponding author: Jung-Eun Cheon, MD, PhD, Department of Radiology, Seoul National University College of Medicine, 103 Daehak-ro, Jongno-gu, Seoul 03080, Republic of Korea
• E-mail: cheonje@snu.ac.kr

of developing bone age prediction models specific to different ethnic populations. This consideration is crucial for ensuring accurate assessment and appropriate clinical intervention in diverse populations. Finally, the study acknowledges the need for further refinement of the model, including the collection of additional training datasets that cover a wider age range, including infants, toddlers, and older adolescents. This highlighted the potential for future improvements in terms of accuracy and applicability.

Since Yeon and Kim [5] published "Atlas of Korean Standard Bone Age" in 1999, it took 24 years to develop a new "Standard Bone Age Model in Korean Children." This represents a new paradigm of artificial intelligence (AI) transformation in radiology. Using a deep learning-based model, researchers efficiently developed a new standard bone age model for Korean children. They proposed an alternative approach to methods used in prior studies by training on data from normal pediatric hand radiographs and using chronological age as the ground truth, as opposed to human interpretation using previously described methods such as GP atlas-based human interpretation. By overcoming the limitations imposed by training using human-generated ground truth data, researchers can develop applications capable of providing clinically relevant predictions that surpass the capabilities of radiologists without AI assistance.

In summary, this study [8] demonstrates the potential of deep learning-based models to enhance bone age assessment in specific populations, considering their unique genetic, ethnic, and environmental factors. The developed model could offer clinicians a more accurate and reliable tool for assessing skeletal maturation in Korean children and adolescents, ultimately leading to improved clinical decision-making and patient care. Further model validation and refinement are essential for successful implementation in real-world clinical settings.

Conflicts of Interest

Jung-Eun Cheon, the editor board member of the *Korean Journal of Radiology*, was not involved in the editorial evaluation or decision to publish this article. The author has no potential conflicts of interest to disclose.

ORCID ID

Jung-Eun Cheon
https://orcid.org/0000-0003-1479-2064

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